

# Stratospheric seeing and contrast limits for a balloon-borne coronagraph

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## Project Objective

As part of a feasibility study for a balloon-borne, exoplanet observatory (Planetscope, PI: Wes Traub), we sought to answer the question: What contrast limits are set by the natural atmosphere and local thermal fluctuations on board a stratospheric balloon?

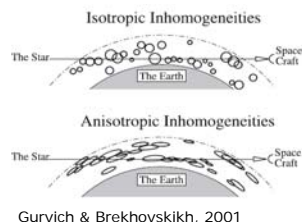
Planetscope's ultimate objectives:

- To directly observe the brightness and color of exoplanets.
- To provide constraints on albedo, diameter, insolation,  $T_{\text{eff}}$ , cloud type, atmospheric pressure, atmospheric composition.
- To search for new exoplanets.
- To image debris disks around nearby stars.

## Recent Accomplishments

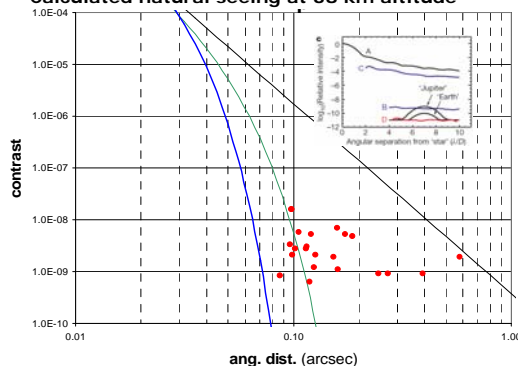
- We calculated the natural seeing (*i.e.* seeing set by the free atmosphere) based on:
  - Scintillation measurements of the middle atmosphere onboard the MIR space station [Gurvich & Brekhovskikh, *Waves in Random Media*, 2001; Gurvich & Chunchuzov, *JGR*, 2003].
  - Hill-Andrews model of atmospheric turbulence.
- To measure local seeing effects, we flew a piggyback laser interferometer onboard the Solar Bolometric Imager gondola (PI: Pietro Bernasconi, Johns Hopkins University).
- This interferometer measured changes in the optical path-length between the outer edge of the gondola and a retro-reflector one meter away (in the surrounding air).

## Project Description



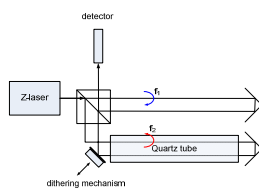
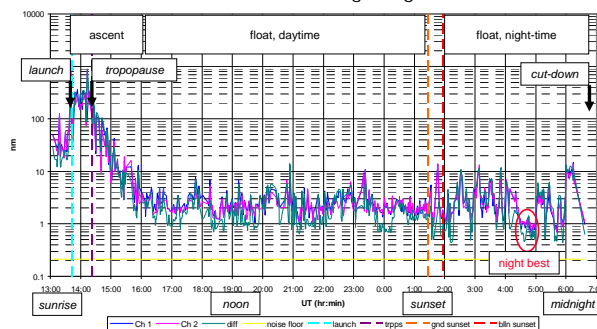
Gurvich & Brekhovskikh, 2001

### Calculated natural seeing at 38 km altitude



At 38-km altitude Ground-based  
 $r_0 = 57 \text{ m}$   $\sim 0.2 \text{ m}$   
 Inner scale = 2.7 m  $\sim 0.006 \text{ m}$   
 Outer = 69 m  $\sim 27 \text{ m}$

### Measured optical path fluctuations in 1-m of air surrounding the gondola



## Benefits to NASA and JPL (or significance of results)

- Original research studying fundamental feasibility limits for directly imaging exoplanets using a balloon platform.
- Balloon-borne observatories can play two important roles:
  - Precursor instrument concept testing to advance TRL values.
  - Scientific advancement at low cost and in the near term, compared to a space mission.
- Direct observations of exo-Jupiters for the first time will be a very significant scientific milestone.